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The ISS Program's Multilateral Coordination Board captured the lessons learned. A summary of this effort as conducted by the ISS International Partners (NASA, Canadian Space Agency, ESA, JAXA, Russian Federal Space Agency) has been published in July 2009 ("International Space Station Lessons Learned as Applied to Exploration," Kennedy Space Center, July 22, 2009).

Agenda

- Lessons learned categories
- Mission objective
- Architecture
- Utilization
- Discussion and conclusions



Slide 3

Categories




- Mission objectives - 6
- Architecture - 22
- International partner structure and coordination - 9
- External communications - 6
- Operations - 3
- Utilization - 8
- Commercial involvement - 2




A total of 56 lessons learned, grouped in 7 categories, have been compiled.

Mission Objectives



- Accommodate each partner's own objectives
- Establish realistic expectations
- Use clear mission objectives to drive support
- Ensure all mission objectives are well integrated




Accommodate partner's own objectives (1st lesson): The most significant outcome of the station mission has been the sustainment and growth of each partner/nation's aspirations for human spaceflight. This occurred because from the onset all partners shared a common objective to build, operate, and utilize a crewed laboratory in low orbit as an international partnership. The partnership was also flexible enough to foster collaboration with other non-partner nations. Application for future: develop a long-term shared vision for space exploration that transcends domestic policies and fosters a shared destiny among the partners.

Establish realistic expectations (2nd lesson): The purpose of the mission should be defined as thoroughly and clearly as possible with planned achievements that are commensurate with planned spending. It is particularly important not to overestimate the mission objectives and scientific outputs. For future: goals must be realistic and well articulated to include the global problems that the mission will help resolve.


Use clear mission objectives to drive support: Properly formulated objectives will ensure stable political and social support. Stages of mission accomplishment must be timely with achievements reported promptly and comprehensively.

Ensure all mission objectives are well integrated: Standardization of technical interfaces and interoperability aspects are critical to success. For the future: functional objectives for the elements developed must be carefully integrated with close attention to technical interfaces and aspects of interoperability and crew safety.

Architecture



- Apply common standards and tools for developing interfaces
- Apply existing interface designs where available
- Implement processes to establish common interfaces with modular design
- Establish core system interface documents early
- Plan for flexibility in design life
- Employ common processes, interfaces, and standards
- Improve technology transfer procedures for common interfaces



Apply common standards and tools for developing interfaces: The actual design of the station interfaces evolved around industry standards where available; but unique interfaces also were created where needed.

Recommendation for future: apply commonly used standards and tools to implement and manage rigorous interface control. Only when absolutely necessary should partners develop unique capabilities to meet unique challenges.

Apply existing interface designs where available: Standardization and unification of appropriate interfaces in basic spheres of interaction (system integration, power, transportation, management, etc.) are critical.

Implement processes to establish common interfaces with modular design: For future: a process to thoroughly address commonality issues and opportunities should be formally established at the highest level early in the exploration program and a modular design approach should be encouraged.

Establish core system interface documents early: Common interface documents should be generated at the onset of the program and should accommodate design options that use state-of-the-art technology, but also provide hooks for enhancements as technology advances.

Plan for flexibility in design life: For future: provide capability for replacing aging systems.

Employ common processes, interfaces, and standards: The standardization of technical interfaces and interoperability are critical to success. In the ISS program, commonality of various interfaces made it possible to simplify the interface definition significantly. Common partnership


interfaces and standards create a common operational environment that leads to on-orbit flexibility and adaptability as situations evolve.

For future: agreements to utilize common processes, interfaces, and standards are necessary to build in flexibility and adaptability for future missions. Commonality of interfaces should be achieved as much as possible in the exploration program.


Improve technology transfer procedures for common interfaces: There are numerous obstacles in transferring technical information regarding the common interfaces.

For future: improve the procedure for technical information regarding the common interfaces.

Utilization



- Use available space assets as technology test beds
- Recognize value of prior exploration programs




Use available space assets as technology test beds: (This lesson learned made my day) The ISS Program used the Shuttle and Mir Station technology test beds and now ISS is serving as a test platform for development and qualification of space technologies.


For the future: Exploration programs should use the ISS to develop, demonstrate, and qualify next generation space technologies and operations relevant to the future of space exploration. The ISS partnership can accommodate non-partner use of the ISS for development and qualification of space technologies.

Recognize value of prior exploration programs: The ISS leveraged considerably from the value of previous human and robotic space exploration efforts. In addition, the ISS allows us to perform many complex hypothesis-driven studies requiring human intervention or monitoring.

Discussion and Conclusions



- Standardization and unification of interfaces in systems integration, power, transportation management, and interoperability are critical to success
 - Common interfaces and standards create a common operational environment that leads to on-orbit flexibility and adaptability
 - Commonality of interfaces makes system simplification possible
- Need to apply commonly used standards and tools to implement and manage rigorous interface control
 - Common interface and interoperability approaches should be created early in the program and should employ state-of-the-art design options, but also allow for future enhancements
- International standardization could provide a framework where early approaches could be explored and agreed on
 - Future exploration missions will undoubtedly benefit (flexible systems, adaptability, shortening schedules)



More than 10 percent of lessons learned from ISS design and operations relate to the critical importance of standards.